**Introduction**

Childhood overweight and obesity rates have tripled nationally over the past three decades1, 2. The prevalence rates of overweight and obesity are distinctly higher in low-income and ethnic minority children3, 4. The CDC considers children overweight or obese with a body mass index (BMI)-for-age equal to or greater than the 85th and 95th percentile, respectively5. The recent reports from school health assessments revealed higher rates of childhood overweight and obesity in California schools compared to national rates6. The 2008 Pediatric Nutrition Surveillance Survey (PedNSS), , identified the combined prevalence of overweight and obesity in Butte County as 47% for Latinos, African Americans, and Native Americanslow income children and adolescents aged 9-117.

High BMI in youth is associated with a number of comorbidities, including increased risk for hypertension8, 9, 10. The diagnostic criteria for childhood hypertension is an average blood pressure (BP) reading greater than or equal to the 95th percentile for sex, age and height on at least three separate occasions. Children that have an average BP reading greater than or equal to the 90th percentile for sex, age and height on at least three separate occasions or BP readings greater than or equal to an absolute value of 120/80 mmHg are considered pre-hypertensive11. Elevated BP (EBP) and pre-elevated BP (pre-EBP) consist of any measurements that have been taken, but do not meet the necessary diagnostic criteria.

National survey data suggests that the prevalence of childhood EBP is on the rise after nearly 30 years of decline12, 13. This trend is following approximately one decade behind the rise in childhood overweight and obesity rates. While cardiovascular disease (CVD) risk screening is a common consideration for adults, recent findings have revealed that America’s youth are presenting with a number of concerning biological indicators such as dyslipidemia, elevated fasting glucose, and increased C-reactive protein14-16.

Due to the unfortunate fact that the majority of youth with hypertension go undiagnosed, clinicians and organizations, such as the National Institutes of Health (NIH); National Heart, Lung and Blood Institute (NHLBI); and the National High Blood Pressure Education Program (NHBPEP) recommend screening youth early15-20. These recommendations stress the importance of identifying and controlling EBP at a young age to help reduce the risk of CVD and stroke later in life. However, BP measurements are not currently required for children. 21. When BP is recorded, evidence suggests that hypertension remains underdiagnosed and is often not addressed22. Implementing regular BP measurements in youth could alert school nurses and health professionals to address the modifiable risk factors that are associated with adult CVD risk.

The data from national surveys indicate the prevalence rates of EBP vary across ethnic groups and sex9, 12, 13. From 1988-2002, EBP prevalence increased significantly for Mexican American males and white females, while pre-EBP increased for blacks and Mexican Americans13. Using data from 1988-2006, Ostchega and colleagues found overweight males and obese males and females were significantly more likely to have pre-EBP/EBP after controlling for age, race/ethnicity and BMI12. A recent investigation of US adolescents revealed that almost half of the youth in America have at least 1 biological CVD risk factor9.

Two separate school-based health screenings were conducted from 2003-2005 in Houston area schools23, 24. These investigations were able to gather multiple measurements in order to meet the diagnostic criteria for prehypertension/hypertension outlined previously11. In the first study, Sorof and colleagues reported a significant increase in the relative risk for hypertension among males and overweight BMI status23. The follow-up health screening reported that only BMI status was significantly associated with hypertension24. School-based screenings in California revealed high rates of EBP in overweight and obese Latino and African American youth25. A screening conducted in close proximity to the geographical region of this investigation found higher rates of pre-EBP/EBP in Native American 5th-8th grade students26. In all school-based health screenings, increased BMI was consistently among the strongest independent predictors of pre-EBP/EBP23-27.

Elementary schools in California have a unique opportunity to implement a screening measurement for EBP in youth. California schools are required to conduct and report FITNESSGRAM® assessments for fifth, seventh, and ninth grade students28. The FITNESSGRAM® assesses physical fitness and body composition (in the form of a BMI measurement). Findings from the Bogalusa Heart Study have illustrated that the BMI measurement is effective in predicting metabolic risks, including EBP29. Based on the relationship between adiposity and BP, school assessments like the FITNESSGRAM® that include a measure of body composition are propitiously placed to identify youth at risk for EBP.

Obtaining a BP reading is less arduous and requires less equipment and personnel training than other measures of obesity comorbidities such as HbA1c, serum cholesterol, fasting glucose, etc. 30. Conducting the BP measurement concurrently with a BMI measurement is an inexpensive opportunity to screen children for risk of EBP. This is particularly advantageous for low-income, racially/ethnically diverse schools where rates are expected to be higher. Furthermore, multiple measurements throughout childhood and adolescence (fifth, seventh, and ninth grade) can provide longitudinal data for more comprehensive medical records.

The primary objective of this investigation was to utilize the FITNESSGRAM® opportunity to assess overweight and obesity as an independent risk factor for EBP among fifth grade students in five low-income schools in northern California. A secondary objective was to examine associations among BP, BMI, race/ethnicity and sex.

**Methods**

*Participants*

Data were collected from a convenience sample of 166 fifth grade students in five low-income schools for this cross-sectional health screening investigation. A school was considered low-income if at least 50% of its students were eligible for free and reduced priced meals. Researchers distributed informational permissions slips and participation was contingent on parental signature. Of the 247 5th grade students, 63% returned parent permission slips and were included in this study. The protocol for this study was approved by the Human Subjects Review Committee at California State University, Chico.

*Procedure*

Data were obtained using a health screening document that consisted of the following self-reported information: teacher name, student identification number, sex, age, date of birth, and race/ethnicity (White, Asian, Hispanic and other). Trained researchers assisted by a school nurse took height and weight measurements using a Seca 216 Accu-Hite® medically approved stadiometer and scale. BMI was calculated using height measured to the nearest 0.5 inches and weight to the nearest 0.5 pound. Date of birth (DOB) was self-reported and verified by school nurses. Age and sex-adjusted BMI percentiles were calculated using current CDC growth charts. Normal weight, overweight and obesity were classified by CDC definitions as a BMI-for-age less than, equal to, or greater than the 85th percentile and 95th percentile, respectively5. Underweight students were combined with normal weight students do to the limited sample size in this category.

Blood pressure (BP) measurements were taken by trained researchers using an appropriately sized Omron® automated BP cuff on the student’s dominant arm. Measurements took place after the participants had a 15 minute rest period to ensure capturing a resting heart rate. The diagnostic criteria from the national guidelines recommend several measurements at different times11. In the present study, BP was measured a single time. If the initial BP measurement was elevated, a secondary confirming measurement was performed. In order to delineate our terminology from the terminology in the guidelines, all participants were categorized in the following manner: participants with a BP reading indicating hypertension risk (defined as systolic or diastolic readings greater than the 95th percentile for age, gender and height) were identified as EBP; a BP indicative of pre-hypertension risk (defined as systolic or diastolic readings between the 90th and 95th percentile for age, gender and height) was identified as pre-EBP; finally, any reading with an absolute value equal to or greater than 120/80 mmHg or the 90th percentile for age, gender and height was considered pre-EBP11. This approach is similar to the methods used by Din-Dzietham et al and Ostchega et al12, 13. All measurements were supervised by a school nurse and the first author.

*Data Analysis*

Data were analyzed using SPSS version 19, 2011, SPSS Inc., Chicago. IL. Descriptive statistics consisted of means, percentages, and standard deviations. The independent variables in this study were BMI-for-age classification, sex, and race/ethnicity. The dependent variables in this study were systolic and diastolic BP (mmHg), BMI classifications and BP risk category classifications. Pearson chi-square tests were used to compare BMI classifications across race/ethnicity groups and sex. Analysis of variance was used to compare mean systolic and diastolic BP across BMI and race/ethnicity groups. An independent t-test was used to compare mean systolic BP values between sexes. Multiple logistic regression models were used to predict overall EBP risk. Statistical significance was set at α < 0.05.

**Results**

Demographic characteristics for the 166 fifth grade students from the low income schools are shown in Table 1. Five percent of the students sampled presented with an initial BP reading ≥ 90th percentile for age, gender and height with 16% of students having a reading ≥ 95th percentile, for a total of 21%. Eighteen percent of the study participants were overweight and 14% percent were obese, indicating an overall prevalence of 32% with a BMI-for-age ≥ 85th percentile.

There was a significant relationship between race/ethnicity and BMI (χ2 6 = 17.0, *P* = 0.01). As shown in Table 2, BMI classification was not equally distributed among ethnicities. Hispanic students had the highest proportions in the overweight/obese BMI categories (54.7%). White and Asian students had considerably lower percentages in the overweight/obese category (25.4% and 16.6%, respectively). Chi-square tests indicated there was no relationship between BMI categories and sex (χ2 2 = 1.75, *P* = 0.42).

A comparison of mean systolic and diastolic BP readings (mmHg) was conducted across BMI-for-age groups (normal weight, overweight, obese). One-way ANOVA tests indicated a significant association between BMI-for-age groups and mean systolic (F2, 163 = 8.49; *P* < 0.01) and diastolic BP (F2, 163 = 5.80; *P* < 0.01) (Figure 1). Post-hoc comparisons revealed that both normal weight and overweight students had significantly lower systolic and diastolic BP readings than obese students. The independent t-tests showed no significant differences in mean systolic (t164 = 0.807, *P* = 0.42) and mean diastolic (t164 = -0.604, *P* = 0.50) BP between sexes. The one-way ANOVA test indicated no racial/ethnic differences in systolic or diastolic BP readings. However, at 109 mmHg vs. 106 mmHg, Hispanic students presented with the highest (non-significant) mean systolic BP reading compared to their non-Hispanic peers, respectively.

Multiple logistic regression models were used to assess the strength of association between BMI-for-age and overall EBP risk (any systolic or diastolic readings greater than the 90th percentile for age, gender and height or an absolute value equal to or greater than 120/80 mmHg). Covariates included sex, age and race/ethnicity (Table 3). Obesity significantly predicted systolic EBP (OR, 5.17; 1.43-18.66) and diastolic EBP (OR, 8.24; 2.71-25.05) risk. Overweight status significantly predicted diastolic EBP (OR 3.96; 1.24-12.60) risk. Obese students were 8.16 times more likely to present with a BP reading that was ≥ 90th percentile (*P* < 0.01) compared to normal BMI category students. When BMI status was dichotomized (underweight/normal weight vs. overweight/obese), the overweight/obese students were 3.70 times more likely to have a BP reading ≥ 90th percentile (*P* < 0.05) compared to normal BMI category students (data not shown). Age, sex, and race/ethnicity were not significant predictors of overall EBP risk.

**Discussion**

The link between excess adiposity in youth and the clustering of CVD risk factors remains a growing public health concern. The results from this health screening indicate that 32% of these fifth grade students were overweight or obese. The prevalence of overweight and obesity was highest among Hispanic students. The prevalence rates of childhood overweight and obesity in this study were similar to those reported by previous studies in the same region6, 26, 27. The rates found in this study were lower than those reported in the state PedNSS, however this discrepancy is likely due to the difference in sampling methods7. These findings are also consistent with local and national data1, 2, 10.

The prevalence of EBP after the initial screening resembled those reported in previous school health screenings10, 23- 27. Obese students had significantly higher systolic and diastolic BP readings than their overweight and normal weight peers. The multiple logistic regression models revealed that an obese BMI was useful in predicting EBP risk after controlling for sex, age and race/ethnicity. Although Hispanic students were disproportionally overweight and had higher (non-significant) BP values than other students, this race/ethnicity was not an independent risk factor for EBP. This finding is inconsistent with studies that included sample sizes13, 25, 26. It is likely that significant differences would be identified among race/ethnic groups with a larger sample from the study population. The link between obesity and EBP demonstrated in this investigation is consistent with other investigations and supports the usefulness of BMI as a screening tool for increased risk of EBP23-27.

A recent report from the American Academy of Pediatrics evinced that at least one CVD risk factor was present in nearly half of the nations’ overweight children and in almost two-thirds of obese children9. BP screenings represent an efficient, inexpensive way to identify children that may be at risk for future health complications. Recommendations for regular early health screenings that include BP measurements have been made for children as early as preschool; however there are few mandatory national school-based health screenings that include BP measurements17, 18. Fortunately, anthropometry is currently part of the mandated fitness measurements in California and Delaware. The FITNESSGRAM® is currently being used by many school districts nationwide and, thus, could be used as a medium for screening EBP risk28. Early identification of CVD risk factors like EBP is important in youth in order to implement lifestyle and behavior modifications. Hypertension does not have to be a “silent killer” if it is detected and controlled in childhood.

This study design required parent permission for the data collection and, therefore, limited the sample size and introduced a selection bias. The measurement of BP was not a clinical diagnosis and may also contain one-time artifacts. The strength of this study is its focus on low-income, ethnically diverse elementary school children. In conclusion, using anthropometric measurements to screen EBP risk would serve as a pragmatic tool for school health professionals. The health screening results presented in this report attest to the need for future research on the prevalence of overweight, obesity and EBP in youth, particularly in socioeconomically disadvantaged areas.